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SITE (Superfund Innovative Technology Evaluation) Demonstration of the Shirco Infrared Incinerator

Enviresponse, Edison, NJ

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16. ABSTRACT

A Shirco Infrared System used for a removal action at a PCB-containing oil refining waste site in Brandon, Florida (a suburb of Tampa) was evaluated. The evaluation included a determination of toxics in the material being decontaminated as well as all the effluent streams such as ash, air emissions and wastewater. These streams were analyzed for heavy metals, organics, dioxins, furans as well as NO_x, and inorganic acids. Leaching tests were performed on the ash. The results indicated that the PCB was reduced from 5 to 100 ppm to less than 1 ppm in the ash, which was the purpose of the removal action. Although research had indicated that the lead compounds in the ash would become insoluble because they would be complexed with carbon, the ash could not be considered non-leachable based on the EP toxicity tests.

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ABSTRACT

A Shirco Infrared System used for removal of an oil refining waste containing organics and PCB was evaluated. The evaluation included a determination of toxics in the material being incinerated as well as the effluent streams such as ash, air emissions and scrubber water blowdown. These streams were analyzed for heavy metals, organics, dioxins, furans, NO_x and inorganic acids. Leaching tests were performed on the ash. Results indicated that PCB was reduced from 3 to 6 ppm in the feed material to less than 1 ppm in the ash. The lead concentration in the ash remained about the same as in the feed. Lead was leachable in the ash based on EP toxicity test.

Summary

The Superfund Innovative Technology Evaluation (SITE) program was started in 1987. The purpose of the SITE program was to demonstrate new or emerging technologies for cleanup of Superfund locations.

One of these technologies is the Shirco Infrared System, a furnace which incinerates a waste on a traveling belt under infrared heaters. A secondary fossil fuel fired chamber (afterburner) is included with the unit to destroy any products

of incomplete combustion (PICs) that are formed in the primary section. An air pollution abatement system, a venturi scrubber followed by a horizontal packed tower and demister, were also a part of the unit evaluated.

Originally, plans were made to characterize a pilot-scale Shirco unit. However, the first full scale (100 ton per day) unit was already being used for a removal action by EPA's Region IV and the SITE program was asked to characterize it.

The test described in this paper took place at Brandon, Florida (near Tampa) at an area which had been a recycle-oil refinery. The material treated was in a lagoon and appeared to be a thick, black oil. Tests had indicated the lagoon material contained organics and 5 to 100 ppm PCB. This lagoon material was too thick to pump and had to be mixed with sand and/or soil surrounding the lagoon before it could be handled by the traveling belt in the primary chamber of the Shirco System. The original material was acidic and was neutralized with lime to reduce corrosion in the material handling equipment and furnace. Feed for the furnace was sized to less than one-inch diameter. It was then weighed and introduced into the conveying system and Shirco unit.

The purpose of this work was to determine and report the performance of the Shirco system and not to determine if it passed or failed any regulations which might apply.

Based on four sets of data the following results were obtained:

1. The Shirco Infrared Unit successfully reduced the PCB content of the feed to less than 1 ppm which was the object of the removal action. The feed to the Shirco contained 3 to 6 ppm PCB. (The lagoon contents [up to 100 ppm PCB] had been mixed with soil surrounding the lagoon resulting in this low PCB content).
2. The destruction and removal efficiency for PCB in the gaseous exhaust stream averaged greater than 99.999 percent.

3. Essentially all of the PCB was destroyed in the burning process, because PCB was not present in the scrubber water or the ash after burning.

4. Particulate emissions for two of the four test periods during the characterization were lower than 0.08 grains/SDCF.

5. The lead in feed was not fixed into an insoluble lead compound in the ash. The toxicity characteristic leaching procedure (TCLP) indicated the material was leachable at a level higher than the regulated level.

6. An operating cost of about $425 per ton appears to be a realistic projection for the Shirco unit.

BACKGROUND

During the 1950's an oil refinery, Peak Oil, reclaimed used oil by filtration and distillion at Brandon, Florida, a community on the southeastern edge of Tampa. The wastes from this process were dumped in a lagoon on the property at the refinery. This lagoon was located in a sandy soil having a shallow aquifer where the organics and PCB started contaminating local drinking water supplies. The Peak Oil site was ranked on the National Priorities List primarily due to the contamination of the local water by PCBs.

EPA Region IV initiated and supervised a removal action at this site. A Shirco Infrared System having a 100 ton per day rating was purchased and operated by HazTech Inc., an emergency cleanup contractor who was awarded the contract to burn the wastes with the objective of removing the organics and PCB.

PROCESS DESCRIPTION

This was the first full-scale, truck-transportable Shirco Infrared System to be used for thermal decontamination of a hazardous waste. The components consisted of (1) a primary unit with traveling belt for burning the waste, (2) a secondary

unit for afterburning any hazardous or toxic gases from the primary unit, (3) an air pollution abatement system, (4) an exhaust stack for the gases, (5) an emergency stack to protect the air pollution abatement system and employees and (6) a control van having electrical and mechanical controls, emissions monitors and office space. A feed preparation system to screen the feed to less than 1 inch diameter, an ash disposal system and an electric power control station were also necessary for the facility but were not part of the Shirco Infrared System package.

The oil-like material, which had a pH of 2-4 was neutralized with lime and mixed with soil. A coffer dam had been erected around the lagoon and the soil used was between the lagoon and the coffer dam enclosure. This mixture was screened to remove rocks, roots and other foreign material, and limit the size to less than 1-inch diameter. The sized material was weighed and conveyed to the primary unit of the Shirco system.

At the primary unit, a feed distribution system loaded the woven metal belt which carried the material being treated under the infrared heating rods. The belt travel rate was adjustable and at Peak Oil the travel rate was sufficient to keep the feed in the primary section 18 to 19 minutes.

As the belt moved the material through the primary chamber, finger rakes at four locations stirred the material to assure that all the material was exposed to the electrical heating rods. An air flow countercurrent to the feed was introduced by a blower at selected locations as it progressed down and off the belt. Since the feed had a high Btu content, the infrared heaters were not required at all times. The temperatures within the primary unit were often controlled by regulating the air flow at each zone. Air flow controlled the burning rate to generate the desired temperature at four locations within the furnace.

As the material (ash) dropped off the belt it was quenched using a water spray. The quench was water from the scrubber and reduced the amount of scrubber

water effluent for disposal or reprocessing. Disposal of the water "blowdown" was to the local sewage treatment plant after it was analyzed for PCB content and metals to determine that the levels were non-toxic and acceptable at the treatment plant.

Exhaust gases from the primary unit were ducted to the secondary unit for combustion (afterburning). The secondary unit provided about three seconds of retention time at up to 2300°F. Afterburner temperature during the three days of testing averaged 1900°F. Bars in the chamber of the afterburner increased the gas turbulence and promoted complete combustion of the gaseous organics.

An air pollution control abatement system followed the secondary chamber. Air pollution control consisted of a water quench, by a venturi system with a 15-inch minimum pressure drop, and a horizontal packed scrubber and demister. Water for the scrubber contained sodium hydroxide and sodium carbonate to neutralize any acid vapors. The ducts for the gases to and from the air pollution system were fiber-glass reinforced polyester.

The exhaust stack had a deck for sampling with ports at the deck level. Sampling equipment such as pumps and controls were kept on the ground near the base of the stack.

Ash was screw-conveyed out of the primary combustion chamber to an ash hopper. Ash was removed from the hopper to a concrete bunker holding area while it was analyzed for PCB content. After sampling and analysis determined the PCB content was less than 1 ppm, it was relocated in a pile away from the processing area.

During the four day test period, the Shirco unit was fully operational at a 100 ton per day capacity. The feed stream and all effluent streams were evaluated during this period of operation. Three replicate samples (one each day) and a duplicate sample of one of the replicates were taken from the stack gas to be analyzed for PCB, dioxins, furans, semivolatile priority pollutants, volatile organics and heavy metals. Continuous emissions monitors were used for O_2, CO_2, CO, THC and NO_x. Corresponding operating data were collected from the control van while the system was being sampled.

All sampling and analyses for these tests were performed at EPA QA Level II for this evaluation. QA Level II required an approved sampling and analysis procedure before the work was started. During the sampling period audits of the procedures were taken and audits were also made at all laboratories doing analyses.

The tests were conducted for the primary purpose of determining the performance of a full scale Shirco Infrared System. The original waste contained 5 to 100 ppm of PCB. These concentrations were reduced by mixing the soil surrounding the lagoon as a way of handling the waste to the incinerator. Table 1 shows the properties of the feed material. Although the feed material used during the tests was from the same general pile, the composition changed during the test period. An estimated 400 tons had to be sized and stockpiled for the test, however this stockpile was between 200 and 300 tons and a second batch had to be stockpiled to complete the third and fourth days of operation. The high heating value for the first batch was about 2065 Btu/lb and for the second batch was about 1640 Btu/lb. This may have resulted in the primary unit requiring less air for burning on the last two days of testing (more electricity for infrared heating) which could also have resulted in differences in particulate emissions from the batches (see Table 4.) This also accounts for the wide range of metals shown in Table 1 for the feed material.

RESULTS

PCB

The results of the work indicate the PCB content of the ash was less than 1 ppm. The destruction efficiency (DE) for the PCB was 83 to 99.88 percent; this was a weight percent reduction of PCB in the feed to that in the ash. The destruction and removal efficiency (DRE) for PCB averaged 99.99931 percent.

Metals

A total of 30 metals were analyzed in the waste feed, ash and stack gas. The average results of these analyses are in Table 2.

Leaching Test Results

The EP Toxicity test, indicated that lead had a leachability of 31 mg/L compared to a regulatory value of 5 mg/L. These results are in Table 3.

All the other metals surveyed in the leachability tests, did not exceed regulatory levels for EP Toxicity (EPTox) and Toxicity Characterization Leaching Procedure (TCLP).

Dioxins and Furans

Dioxin and furan analyses are required whenever PCB is in the waste. The dioxins were below the detectable limits except for one test out of four for TCDF. TCDF was detected at the 0.47 micrograms/cubic meter when the detection limit was 0.34 micrograms/liter.

Semi-volatile Organics

The stack gas was analyzed for 117 organic compounds and only a small number were detected.

PCBs and POHCs were below the detection limits.

Naphthalene was detected at 1300 mg/m^3 (average) for two of four samples taken. Phenol was detected at 500 mg/m^3. Phthalates were detected, but it is believed these were from the plastic bottles used for the samples.

Sulfur

The sulfur in the feed was 300 lbs per hour and the sulfur in the emissions was less than 2.5 lbs/hr. The removal rate was in excess of 99.9 percent.

Chlorine

The concentration of chlorine in the feed was not detectable and therefore the efficiency of removal (of HCl) could not be determined. The gases were caustic-scrubbed to remove hydrochloric acid and sulfurous acids. Since the sulfurous

acids were harder to remove than hydrochloric acid, the air pollution abatement system must have removed more than 99.9 percent hydrochloric acid.

Cost and Economics

An economic analysis indicated the cost of using the Shirco Infrared System could be as low as $200 per ton of contaminated material, and as high as $800 per ton depending on the amount of material preparation required and the equipment usage rate. A projected realistic average cost per ton of contaminated feed material is $425 per ton.

This paper covers only the work done at Peak Oil, Brandon, Florida. The Shirco Infrared pilot plant system has been used for a SITE program test at Rose Township, Michigan. Results of these tests are still being processed into a report which is in the publication process.

Table 1. Waste Feed Solid Analysis

	nanograms per gram
PCB (Total)	3480 to 5850
heptachlorobiphenyl	940 to 2200
hexachlorobiphenyl	1100 to 1700
pentachlorobiphenyl	200 to 490
tetrachlorobiphenyl	400 to 830
trichlorobiphenyl	570 to 820
dichlorobiphenyl	120 to 190
ethyl benzene	40 to 140
methylene chloride	80 to 120
toluene	130 to 300
xylene	260 to 770
	micrograms per gram
antimony	2.1 to 3.6
arsenic	2.0 to 2.9
cadmium	3.9 to 4.6
chromium	20 to 24
copper	44 to 55
strontium	50 to 62
lead	4400 to 5000
vanadium	7 to 11
zinc	950 to 1100
	Percent
moisture	14.2 to 16.6
carbon	7.0 to 7.8
sulfur	1.8 to 2.5
chlorine	less than 0.1
ash	70 to 75
Btu value (HHV)	1640 to 2065 Btu/lb

Table 2. Metals Analysis

Parameter	ug/g Solid Waste Feed	ug/g Ash	ug/dscf Stack Gas
Aluminum	1625	2500	<210
Antimony	2.15	3.3	91
Arsenic	2.55	2.6	38
Barium	505	757	675
Beryllium,	.168	.3	.11
Boron	NA	NA	625
Cadmium	4.15	4.1	1920
Calcium	37500	50000	1680
Chromium	22	27	270
Cobalt	.75	2	<11
Copper	49	64	420
Iron	2050	2600	440
Lead	4800	6400	58000
Lithium	ND	ND	21
Magnesium	850	1050	180
Managnese	47	55	12
Mercury	ND	ND	<.10
Molybdenum	ND	ND	50
Nickel	8	10	42
Phosphorus	790	770	0
Selenium	ND	ND	3.2
Silicon	NA	NA	780
Silver	2.0	4.0	10
Sodium	5550	5600	18600
Strontium	57	76	10
Sulfur	20500	24000	160000
Thallium	ND	ND	630
Titanium	41	115	<50
Vanadium	9	13	<25
Zinc	1030	1060	9400

ND - Not determined

NA - Not analyzed

The stack gas contained 0.1015 grains/DSCF of particulate (One grain = 64.8 mg)

Table 3. Leaching Test Results

Parameter	EP Toxicity		TCLP Analysis	
	Average mg/L	Regulatory Level, mg/L	Average Level, mg/L	Regulatory Level
Arsenic	0.020	5.0	.007	5.0
Barium	1.35	100	.25	100
Cadmium	.099	1.0	.008	1.0
Chromium	.037	5.0	.037	5.0
Lead	31	5.0	.011	5.0
Mercury	.0015	0.2	ND*	0.2
Selenium	ND*	1.0	.031	1.0
Silver	.031	5.0	.059	5.0
Only TCLP compounds detected are listed below				
Acrylonitrile			.013	5.0
Methylene chloride			.020	8.8
Toluene			.0020	14.4
1,1,1-Trichloroethane			.0006	30
Trichloroethane			.0006	.07

*Not detected

Table 4. Emission Data

Date of Run	DRE for PCB %	Particulate corrected to 7% O_2, grains/DSCF	SO_2 g/hr
8/1/87	99.99967	0.1590	27.6
8/2/87	99.9988	0.0939	1070.0
8/3/87	99.99972		
8/4/87	99.99905	0.0768	22.0
8/4/87		0.0761	20.6
Average	99.99931	0.1015	285.05